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A PRELIMINARY MARKET POTENTIAL INDEXING STUDY OF THE UNITED STATES FOR DIRECT GAIN IN NEW SINGLE-FAMILY RESIDENTIAL CONSTRUCTION*

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ABSTRACT

The evaluation of the market potential for passive solar designs in residential new construction offers an attractive counterpart to the numerous market penetration assessments that have been performed over the last four years. Market penetration analyses have generally concerned themselves with the "long run" adoption of solar energy technologies, while Market Potential Indexing (MPI) addressed here examines the near-term attractiveness of solar. The MPI method is briefly reviewed, followed by specification of six attributes that may characterize the residential single-family new construction market. Raw attribute data for each of the six is presented for 220 regions within the United States. Attribute weighting functions are constructed from the perspective of consumers, producers or home builders, and the federal government. Preliminary results from these three perspectives are portrayed for a fixed sized direct gain design.

1. INTRODUCTION

In 1980, the Economic Analysis Group at the Los Alamos National Laboratory began work on a method for evaluating the potential of passive solar markets. This method, called "Market Potential Indexing" (MPI), is based on multi-attribute decision analysis. Several previous papers have been published describing the method and providing samples of limited studies (1, 2, 3). The purpose of this paper is to present the results of the first preliminary nationwide study using the MPI method.

The overall study addresses the residential, single-family, new-construction market segment and includes Trombe wall, direct gain, and attached sunspace passive solar designs. The results are presented using a method of attribute data normalization that allows comparison both among technologies and among alternative "values" placed on each market attribute. Three sets of attribute-weighting values or factors are used to evaluate the sensitivity of the results to various weighting combinations. The results of the study show that there is a wide variation in market potentials based on the differences in market perspective. The weighting assigned for the consumer perspective resulted in a surprisingly homogeneous set of final MPI values.

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2. MARKET POTENTIAL INDEXING

An economic performance code which evaluates the feasibility of residential passive solar space heating designs (4) has been developed. The model--Los Alamos/UNM EASE-III--is used to provide the technical, economic, and cost input data and structure the geographic market boundaries of the MPI model. This model uses 220 clustered county regions based on the SOLMET (5) weather data base to define a set of highly disaggregated data bases. These data are used as the starting point for the market potential indexing process.

Each local market has a set of common quantifiable attributes that effect local market potentials. These include weather characteristics, solar performance, building costs, and fuel-type usage and costs. By using multi-attribute decision analysis techniques, one can construct a quantitative market potential model that will allow comparison between local markets. The market attributes that are used for the study presented in this paper were developed specifically for the residential, single-family, new-construction market segment.

Equation [1] is the value function used to determine the Market Potential Index value for each of the 220 market regions:

$$P_i = \sum_{j=1}^{6} W_j \, V_j(A_{ij}) \qquad [1]$$

where:

i = the market region index $i=1,\ldots,220$;
j = the attribute index $j=1,\ldots,6$;

P_i = the Market Potential Index value for the ith market region;
$V_j(A_{ij})$ = the value function of the jth attribute for the ith market region; and
W_j = the weighting factor for the jth attribute. ($\Sigma W_j = 1.$)

3. MARKET ATTRIBUTES

The first step in the study was to establish a set of market attributes which met two major criteria. First, the attribute had to uniquely (but not necessarily independently) represent a market place characteristic that has a major influence on the acceptance of solar technologies. Second, the attribute must be capable of being evaluated in all 220 market regions by use of available data sources. The Los Alamos/UNM EASE-III code is capable of providing many pieces of raw input data that can be used to evaluate several attributes. Additional information is available from the National Association of Home Builders, U.S. Bureau of the Census, U.S. Departments of Housing and Urban Development, Commerce, and Labor, the Internal Revenue Service, and others. A discussion of each of the attributes follows. (The attribute values have been developed for a direct gain design using 224ft^2 of south-facing glass with an aperture to mass ratio to 1.0 - 1.5.)

3.1 Attribute Specification

The solar performance attribute defines the dollar value of energy savings that could be achieved by a typical new home. It considers such economic and financial parameters as the total cost of the specified solar system, the present and future cost of conventional fuels, mortgage terms. The fractional breakdown of housing by fuel type is used to "weight" the dollar savings (in present value terms) for each "typical" home by the proportion of new single-family home starts employing major conventional fuels. Fig. 1 provides an example of the value distribution of this attribute.

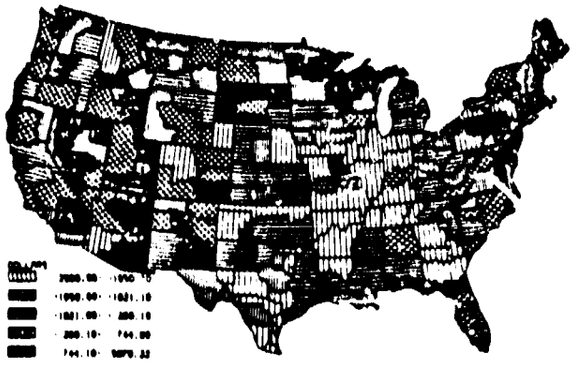

Fig. 1. Attribute 1 - Solar Performance (Net Present Value-1980$)

Relative differences among and rankings of this attribute do provide useful information about the potential for future markets.

The energy market share attribute describes the energy savings that could be achieved if passive solar designs were integrated into all new home construction. The raw attribute values vary by market region according to solar savings fraction by fuel type, fuel type shares in new construction, number of housing starts, and new-construction home heating loads. This attribute is defined as the product of regional housing starts, the Btu displacement for a typical home by fuel type, and the proportion of new homes employing that fuel type. This attribute is shown in Fig. 2.

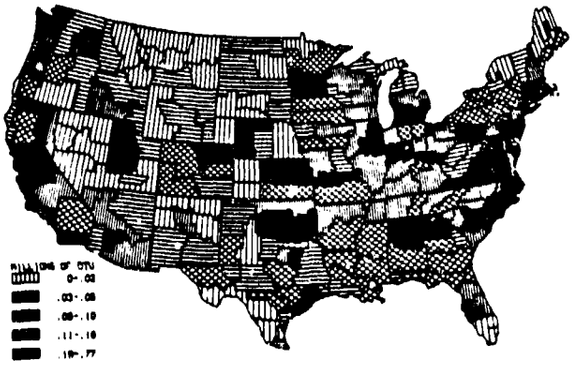

Fig. 2. Attribute 2 - Energy Market Share* (mmBtu/Market Region/Year)

The consumer liquidity attribute describes the consumer's financial obligations and benefits. It measures the consumer's net cumulative cash flow after five years. The net expenditures for the direct gain passive solar design are summed over five years to arrive at the cumulative net cash flow position for each typical consumer for each of the fuel types. Fuel type proportions in new single-family residential construction have been used to weight this attribute to arrive at a composite net cash position value for a "typical" home by region. Fig. 3 geographically portrays these composite net cumulative cash flow values.

The government incentive attribute measures the "value" of state and local governmental incentives available for installation of solar equipment. (It is still uncertain how many of these are really applicable to passive solar designs.) These incentives take the form of tax credits, tax deductions, grants, low-interest loans, other cost deferments, and

*The mapping procedure used in this paper has been developed for illustrative purposes only. The regions are ranked ordered in ascending fashion, with each "keyed" category representing 20% of the total.

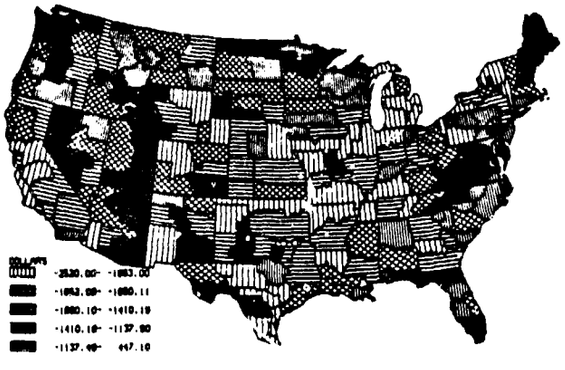

Fig. 3. Attribute 3 - Consumer Liquidity

and general market stimulus. This was a difficult attribute to evaluate because of the number of different types of incentives and implementation schemes. It was necessary to categorize the incentives and then establish an indexing system for each category to establish a system of comparison. Fig. 4 illustrates the qualitative "value" distribution for Attribute 4.

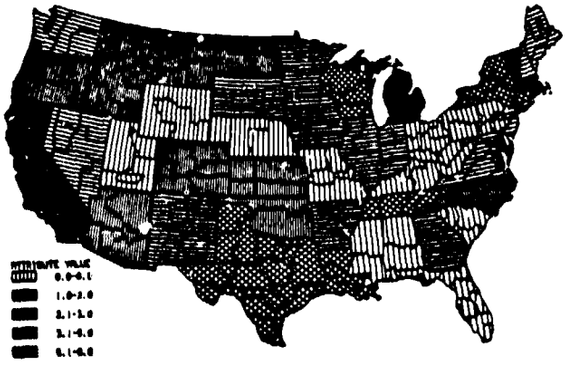

Fig. 4. Attribute 4 - Government Incentives

The income characteristic attribute is a partial measure of the ability of families within the market region to afford new housing. Higher incomes allow for a higher likelihood of home buying qualification and a better ability to pay for solar add-on costs. The value distribution for Attribute 5 is shown in Fig. 5.

The population growth attribute is a proxy for new household formation. The market potential for newly constructed passive solar houses will usually be highest where the demand for new construction starts is highest. (Even though this attribute is not independent of Attribute 2 it was deemed appropriate to include a measure of growth potential as a separate attribute.) The value distribution for Attribute 6 is shown in Fig. 6.

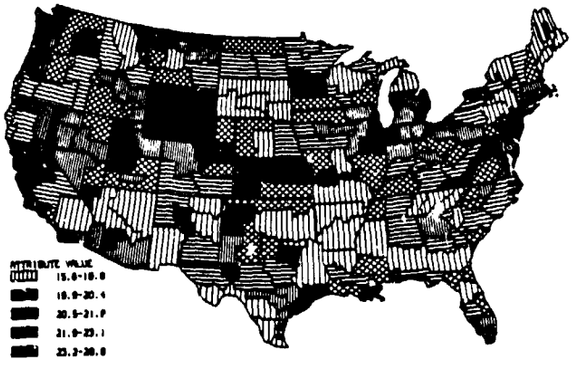

Fig. 5. Attribute 5 - Income Characteristics (Thousands of Dollars/Year/Household)

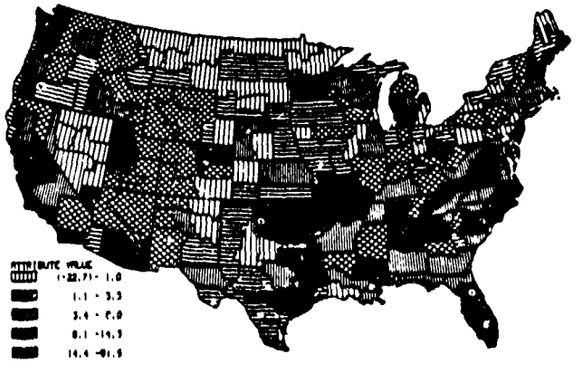

Fig. 6. Attribute 6 - Population Growth (Thousands of Persons/Year/Market Region)

3.2 Attribute Normalization

The attributes are measured in many different dimensions. It was necessary to transform each of these measurements into a dimensionless utility number that reflects its "goodness" or "badness." This is done by developing a transformation function for each set of attribute data. The overall maximum minimum values are determined for the data and a range of values is defined over which the value of the utility function can vary from 0 to 100. Finally, functional relationship is developed that allows a utility number to be evaluated from measured value in the attribute data sets. For this version of the MPI methodology, a line transformation function is assumed. The transformation process involves shifting the zero point and scaling the data to conform with 0 to 100 range of the utility values.

4. ATTRIBUTE WEIGHTING FACTOR EFFECTS

4.1 Development of the Attribute Weighting

The role of the attribute weighting factors is to provide a method of emphasizing or de-emphasizing the effects of the attributes on the market place. It is impossible to determine a single "best" set of weighting factors because of the subjective nature of human behavior. The best one can hope to do is to come close enough to provide useful output from the MPI model. In most cases, the "usefulness" of the data depends on the perspective of the person using the data. Each individual will weight the market factors quite differently.

In order to characterize the effects of the weighting factors on the MPI results, we developed three sets of weighting factors to use with the passive solar technology in this study. The weight factor sets were developed from the perspective of the consumer, the producer, and the government. The weighting factor sets presented here represent a reasonable perspective, and should be used only to illustrate the possibilities for MPI analysis in general. Table 1 lists these weighting factor sets.

TABLE 1

WEIGHTING FACTORS FOR THE SINGLE-FAMILY NEW-CONSTRUCTION STUDY

Attribute	Consumer	Producer	Government
1-Solar Performance	.30	.11	.18
2-Energy Market Share	.05	.30	.26
3-Consumer Liquidity	.40	.08	.18
4-Government Incentives	.10	.06	.15
5-Income Characteristics	.10	.20	.07
6-Population Growth	.05	.25	.16

The consumer weighting factors emphasize those market attributes that affect the "micro" environment. For example, the heaviest emphasis is placed on Attribute 3, "consumer liquidity," which directly affects the consumer's cash flows. The least emphasis is placed on the "macro" attributes such as "energy market share" and "population growth."

The producer weighting factors emphasize the market attributes that will create a climate favorable to new home construction. The heaviest weight is placed on the "energy market share" attribute, which essentially defines the market size. The low weightings are given to the attributes that deal with the consumer's personal finances.

The government weighting factors generally give the "macro" attributes the most emphasis. In particular, the "energy market share" attribute receives the highest weight. The goal of the government weighting is to determine where the best opportunities exist for promotion of passive solar.

4.2 Preliminary Results

One of the questions addressed by this study is: "For a given set of attribute data, how do the market potentials change when the weighting factors are varied?" Each of the attributes exhibits its own geographic distribution (see Figs. 1 through 6). Some of the attributes are distributed by climate and latitude, while other reflect patterns of income and population.

By close analysis of the weighted normalized data, the reasons for seemingly illogical results can be determined. In cases where there is a high weighting on population growth and average household income, the solar performance and energy market share attributes are masked. Since these latter two attributes carry the climatic and solar performance data, overriding them can cause problems.

Use of the three different weighting factors provides data sets with distinctly different distributions. Results from the producer and government analysis are so similar that the same MPI value break points can be used in the figure legends. Data from the consumer analysis was distributed so differently it must be analyzed separately.

The consumer weighting results (Fig. 7) indicate a good market potential through the Midwest and Northeast. Results are heavily clustered between 40 and 50 for most regions; this makes interpretation difficult.

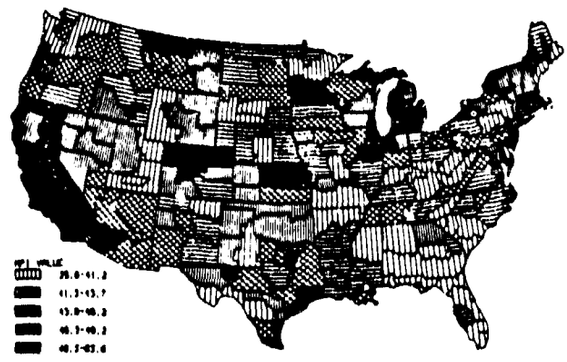

Fig. 7. MPI Values - Consumer Weighting (Dimensionless Index from 0 to 100)

Strong market potential is distributed widely across the U.S. with the producer weights (Fig. 8). Particularly strong potential is indicated for the northern third of the U.S.

Government weighting factors yield lower MPI values (Fig. 9) than with the producer set. Strong market potential is indicated for the

Northern Midwest and Ohio River Valley regions, the state of New York, and the New England region.

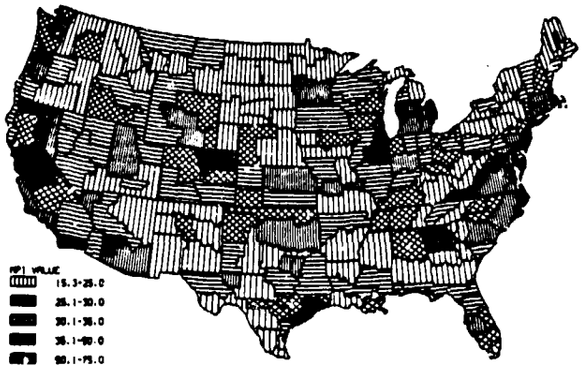

Fig. 8. MPI Values - Producer Weighting (Dimensionless Index from 0 to 100)

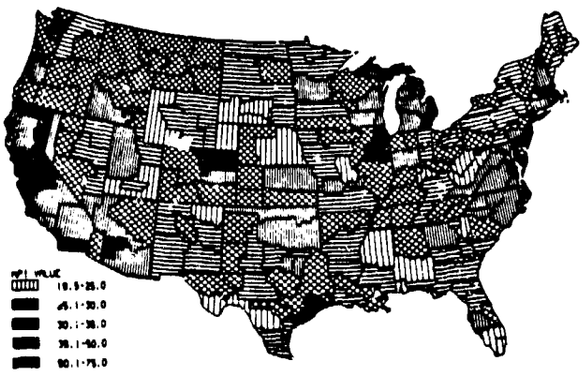

Fig. 9. MPI Values - Government Weighting (Dimensionless Index from 0 to 100)

5. SUMMARY

The results presented above highlight the possibilities and problems involved in the assessment of market potential for passive solar designs in new single-family residential construction. Work continues on differing model specifications for the MPI technique, more realistic specification of market attributes, and attainment of a greater concensus for proper weighting factors. Work is progressing on examining another market segment, the retrofit single-family residential sector.

Note: All raw attribute and MPI figures (maps) presented in this paper must be considered preliminary.

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